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Study of the Radiation Damage of Hamamatsu Silicon Photo Multipliers

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An irradiation test on 16 Silicon Photo Multipliers produced by Hamamatsu has been performed in Louvain-la-Neuve at the CRC-CYCLONE 110 facility.
The devices has been irradiated with neutrons in three dose steps: 5x10ˆ8 1MeV-neutron equivalent (neq), 5x10ˆ9 neq and 5x10ˆ10 neq. After each irradiation step the characteristic current-voltage curves and a high statistics sample of the dark noise waveforms have been recorded for offline analysis.
In the proposed contribution we will present the results on the variation of the main SiPM parameters as a function of the dose for the devices under study, that include as well special “Radiation Hard” designs.

Summary

Silicon Photo Multipliers (SiPMs) are novel solid state photon detectors based on matrices of Geiger mode APDs.
The interest of the scientific community for these devices has constantly increased since their (recent) development, thanks to their very appealing characteristics.
They can in fact guarantee the same performances of standard vacuum tube photo multipliers with many advantages: single photon counting capability, compactness (few mm), low bias voltage (< 100V) , insensitivity to magnetic fieds etc...
They have also a few drawbacks though, like the high dark noise rate and the radiation damage, which cause a degradation of the main parameters (i.e. gain, dark noise, photon counting capability...).
The first issue has been addressed by the manufacturers, with significative improvements in the last years.
The radiation damage is, instead, an intrinsic effect that is of paramount importance to understand, especially for applications where a high radiation environment is expected (like in High Energy Physics experiments).
SiPMs producers are prototyping new devices to face this issue and it is very important to have a feedback from the final users.

In the proposed contribution we will present results of the irradiation test of 16 SiPMs from Hamamatsu, including non commercial “Radiation Hard” devices. The sample under study is made of 16 SiPMs with the same geometrical parameters (a square 1x1 mm2 active area and 50µm pixels) but realized with 8 different constructive methodologies (2 SiPM per type).

The devices have been irradiated with neutrons in Leuven la Neuve at the CRC-CYCLONE 110 facility, with integrated 1 MeV equivalent doses of: 5x10ˆ8 neq, 5x10ˆ9 neq and 5x10ˆ10 neq. (values where is maximum the rate of change of the performances.).
The experimental setup consisted of: a custom made PCB, for the mechanical support, bias and readout of the SiPMs signals; a commercial National Instrument CompactRIO system, for the readout of the currents and of the temperature; a high performances waveform digitizer (5GS/s, 12 bits) and a Keithley picoammeter for the I-V curves.

After each irradiation step and for each device, we measured the current versus voltage (I-V) characteristic curve and, thanks to the high resolution wavewform digitizer, we stored a high statistics (100 k-events per SiPM) sample of dark noise signals. The offline analsysis of the above data will allow us to measure the change

in the main parameters of the devices: dark current, dark noise (rate and spectra) and, possibly, the gain (for the latter parameter, it can be measured as long as the single photo electron peaks are visible).

The results of the above measurements will be presented.

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